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A RESEARCH AND DEVELOPMENT RESPONSE TO EMERGING THREATS

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EXECUTIVE SUMMARY

The world will pose a number of challenges to America's national security interests over the next 10-15 years. The United States certainly will continue to face, and seek to resolve, serious humanitarian crises, peacekeeping and peacemaking situations, and small-scale military contingencies where they affect significant American interests. In recent years, the United States has been cultivating security approaches that aim to reduce and avert threats to global security through cooperative threat reduction programs, by limiting arms buildups, and resisting the proliferation of weapons of mass destruction. Such proactive approaches will likely be even more important tools for moderating future threats in the years ahead. Nevertheless, many challenges will not be resolved in this way, and large numbers of US forces are likely to be deployed overseas for such missions. Moreover, at least a few larger threats to American and allied interests will be posed by regional powers dissatisfied with the political *status quo*, and the United States will sometimes have to take the leading role in containing them. These adversaries will seek ways to deter US intervention in regional conflicts, especially by threatening the American homeland, allies, or our forces overseas with chemical, biological or nuclear weapons, by trying to disrupt our economic and information infrastructures, or sponsoring terrorist attacks. If adversaries fail to deter our intervention, they will attempt to hamper our deployment to overseas bases, and they will try to develop niche high-tech military advantages in order to inflict unacceptable casualties on American and allied forces.

Current priority programs. To meet our global responsibilities, America's foreign policy initiatives and military forces will need to be supplied with the latest technologies, which are carefully suited to a changing set of tasks. Threat Reduction research and development at Los Alamos National Laboratory is providing advanced science and technology to keep the US ahead of its adversaries in this new environment. Important research programs are providing improved capabilities for surveillance and warning, technologies to assure compliance with treaties and agreements, technical systems and cooperative activities to reduce the spread of weapons of mass destruction, and science and technology to counter future military threats.

A new initiative. Despite our best efforts, we expect that asymmetric military threats to America's interests, especially biological and nuclear weapons and their delivery systems, will grow in the next two decades, posing an especially dangerous threat to our allies, our forces overseas, and to the United States homeland. An effective counter to

this threat will not be possible without an understanding of activities in denied areas at an unprecedented level of detail. We will also need the ability to track and counter weapons of mass destruction should they, nonetheless, appear on our shores. This will require truly revolutionary advances in sensors, information processing, and analysis, all assembled into an integrated capability. The time has arrived when focused research and development can give us these capabilities. Los Alamos is developing an important new initiative that, integrating the resources of the three DOE NNSA national laboratories, can provide the nation with unmatched warning of emerging WMD threats, and a level of understanding that will allow the country to neutralize those threats before they can do harm.

Next steps:

For Russia threat reduction programs
- Continue support for securing and irreversibly eliminating excess nuclear materials
- Downsize the Russian nuclear weapon complex
- Expand the "second line of defense" activities and create a Russian NEST capability
- Reduce production of new plutonium in Russian reactors and support development of proliferation-resistant reactors

For enhanced nonproliferation
- Extend safeguards by implementing wider-scale environmental monitoring
- Find ways to reduce risks emanating from the buildup of civil plutonium in spent fuel
- Improve nuclear weapon monitoring, and transparent warhead elimination techniques
- Complete and deploy more sensitive nuclear testing detection sensors
- Develop more sensitive remote and close-in monitors to detect CBW development and production

For countering proliferation and terrorism
- Reduce the time needed to detect and fully characterize CBW events, to allow for treatment
- Improve technical tools for training and coordinating responses to WMD incidents
- Create a system to detect covert delivery of nuclear weapons against critical areas

To support Defense Department science and technology needs
- Create overarching partnerships between DOE NNSA labs and major DOE entities, so DoD can use the labs more efficiently, while supporting the lab tech base

To protect the critical national infrastructure
- Develop tools to understand the vulnerabilities of individual critical infrastructures, the complex relationships among them, and ways to mitigate those vulnerabilities.

To leap ahead in countering WMD threats
- Support Los Alamos as it creates a revolutionary capability for the real-time detection, analysis, understanding, and support for responses to weapon of mass destruction threats.

GLOBAL, REAL-TIME UNDERSTANDING OF WMD THREATS: A RESEARCH AND DEVELOPMENT RESPONSE TO EMERGING THREATS

I. Emerging National Security Threats

The United States, over the next 10-15 years, must be prepared to respond to a variety of challenges ranging from humanitarian crises through small-scale military contingencies, to major theater war. At the same time, the United States will need to continue to have the means to deter existing and emerging states that possess weapons of mass destruction, while remaining watchful for the emergence of a peer adversary in the more distant future. For the nearer future, the United States will need to respond to a world which has seen a major shift toward lower-level, more limited military threats, but more of them. This turbulent and rapidly changing global security environment contrasts with the massive, unitary, but stable threat environment of the final decades of the Cold War.

These emerging threats will often challenge important US interests, especially in settings where states seek to shift the regional balance in their favor, thereby undermining the regional status quo and threatening regional stability. Such actions could indirectly threaten vital US interests by undermining the global/regional political, economic, and military stability on which the American alliance structure depends. Direct challenges to vital US interests, or the crucial interests of major US allies, will include the acquisition by potential adversaries of weapons of mass destruction (WMD), potential state sponsored acts of terrorism against the US homeland or interests abroad, and a limited number of possible regional actions such as interrupting the flow of Gulf oil.

Regional powers will find it hard to compete directly against technically superior US military forces. Most often, adversaries will rely on strategies that avoid direct military conflict with the United States and its allies by deterring US/allied interference in regional conflicts. They could seek to intimidate nearby friends and allies whose support for US forces is essential. They could threaten the American (or allied) people directly with limited numbers of long range ballistic or cruise missiles, carrying, nuclear, chemical, or biological weapons. Adversaries might demonstrate their ability to disrupt economic and information infrastructures, or they might sponsor terrorist attacks against the US people, allies, or forces overseas. And, to exploit America's aversion to casualties, they could promise to inflict large numbers of casualties among US forces.

If adversaries contemplate actual war with the United States and its allies, they know that the United States, and to a lesser extent our allies, will have superior forces and technology, but that the United States must operate as an expeditionary military force. So they are likely to try to defend against US forces by seeking out weaknesses in US power projection capabilities, and attempting to develop niche high-tech military advantages. Promising approaches to countering US technical strengths include denying sea and air access to US expeditionary forces, and hiding their own forces in terrain and foliage (looking to Vietnam rather than the Gulf War as a model). Adversaries also will employ sophisticated denial and deception techniques against US intelligence and targeting systems, embed critical targets in urban populations, and attack the military information systems on which US military superiority will increasingly depend.

In an actual war, adversary states may try to weaken the United States, avert defeat, and drag out a conflict by threatening or launching attacks on chinks in US defenses and on the determination of the US and its allies to continue the war. Asymmetric strategies could include employment of biological, nuclear, or chemical weapons against force concentrations, ports, airfields, bases, and logistic trains. Such attacks could be delivered by conventional military means (e.g., ICBMs or stealthy cruise missiles), or surreptitiously by special forces or state-sponsored terrorists. Adversaries could direct attacks at the US population generally, at sensitive national nodes such as important war-supporting cyber and physical infrastructure, or at US forces and allies abroad. Sub-state entities like terrorist organizations, pursuing their own agendas, might also be able to employ some of these techniques.

Russia and China, major powers with long-range nuclear forces, will retain the capability to threaten vital US interests, perhaps national survival, should they become adversaries. Current American policy seeks to provide a passive deterrent against their strategic power while encouraging their incorporation into a peaceable global system. However, Russia and China continue to express their opposition to what they see as overweening US military and political power, assertiveness, and overseas adventurism. They are likely to continue encouraging the formation of an informal coalition of states to resist US foreign and defense interests. They might also reject US efforts for political accommodation and, depending on domestic developments, emerge as peer competitors of the United States in the more distant future.

In the context of its reduced expanse and the budget-driven decline of its general-purpose military forces, Russia has increased its reliance on nuclear weapons. This includes renewed interest in using tactical nuclear weapons to defend Russia against invaders, and possible modification of existing weapons or development of new delivery systems and nuclear weapons for this purpose. Such a development could increase the likelihood that nuclear weapons would be used in a future conflict, even one that did not immediately involve the United States.

In general, the strategic nuclear forces of Russia are likely to decline in number, while those of China will grow and modernize toward the size of French, British, and perhaps even Russian forces. To the extent that this happens, the United States will need to review the appropriate size of its nuclear forces in the future and the roles they should continue to play. This review would likely consider how best to provide effective deterrence, in combination with missile defenses and non-nuclear offensive capabilities, which does not cause first-strike or arms race instability.

Historically, arms control and international nonproliferation regimes have been a leading mechanism for shaping security threats and determining US force needs. In today's less-threatening strategic environment, it is not yet clear if traditional bilateral and multilateral arms control will continue to play a central role, if informal approaches to arms control and reductions will become more prevalent, or if negotiated power relationships will give way to unilateral definition of national security requirements. But in all of these cases, information about the military capabilities of potential adversaries, transparency measures to provide information regarding fulfillment of informal agreements, or effective verification of formal agreements will remain a high national priority for the United States. In particular, the United States may or may not decide to ratify the Comprehensive Test Ban. In either case, because it is likely that the current moratorium on nuclear testing will continue, the Stockpile Stewardship Program will likely remain a key priority, as well as monitoring and analysis of foreign nuclear weapon development and testing.

It is in the context of this uncertain and dynamic threat environment that Los Alamos Threat Reduction programs are committed to help strengthen threat warning, assure compliance with treaties and agreements, reduce the likelihood of the proliferation of weapons of mass destruction, and counter threats to the US homeland and overseas vital interests.

II. Threat Reduction Programs

A. <u>Cooperative Russia Programs.</u> The breakup of the Former Soviet Union (FSU) dramatically increased the danger that nuclear weapons expertise could be transferred to countries of proliferation concern, or that materials associated with nuclear weapons, even nuclear weapons themselves, might be stolen and transported to hostile countries or terrorist groups. In the early 1990's the Cooperative Threat Reduction (CTR) program was initiated to deal with this threat. Today the US, with support from the Department of Energy's national laboratories, is engaged in several important cooperative programs with Russia and other FSU states to protect and reduce the amounts of nuclear materials and reduce the size of Russia's nuclear complex.

Under the CTR program, a storage facility is under construction at Mayak in Russia to store fissile material no longer needed by Russia's nuclear weapon program. Technical measures are needed to ensure that nuclear materials arriving at the site do in fact come from the Russian nuclear weapon program. Los Alamos National Laboratory recently hosted a demonstration of a prototype nuclear measurement and information barrier system that provides assurance of weapon origin without compromising sensitive or classified information.

The material disposition program is designed to eliminate nuclear materials that the United States and Russia have committed to remove from their weapon programs. Measurement technology has been developed to ensure that diluted uranium purchased by the United States from Russia originated in weapon-grade material. Los Alamos has also developed an environmentally friendly process called advanced recovery and integrated extraction system (ARIES) which converts weapon cores ("pits") into a form suitable for burning in conventional nuclear power reactors. ARIES has been selected as the basis for an industrial scale conversion plant to be built at Savannah River. This plant will convert tons of excess US weapon plutonium into non-weapon form. We are working with Russian experts to develop a comparable method in Russia for conversion of their excess weapon plutonium to non-weapon form suitable for elimination.

Another program, materials protection, control and accounting (MPC&A), is securing nuclear weapons materials at defense facilities throughout Russia, to date resulting in significant security enhancements for 70 percent of the nuclear materials at Russia's Ministry of Atomic Energy (MINATOM) locations. As part of this program, Los Alamos' expertise in nuclear measurements and computerized accounting systems has been transferred successfully to several Russian nuclear sites.

But the job is not finished. Efforts to secure weapons and materials in Russia, to ensure irreversible removal from weapon programs, and to downsize Russia's production complex will likely require continued efforts over decades.

While increased security and protection measures are being put in place, efforts to establish the so-called second line of defense have barely begun. The second line of defense would establish check points at borders and transit sites in Russia looking for contraband nuclear materials before they can get out. Likewise, there is a need for a portable search capability to find material in case it goes missing. If an entire weapon is lost or stolen, or there is a threat that such an event may have occurred, Russia needs a NEST-type capability, similar to the US, to locate and deactivate the device. These measures, if implemented, would afford cheap insurance against nuclear theft or terrorism, which could cause serious harm to the US or allies, while MPC&A and other programs are affording increased protection at the nuclear sites.

Efforts to secure and eliminate nuclear materials are being accompanied by programs to downsize Russia's nuclear complex. Los Alamos is participating in a project to convert part of the nuclear weapon institute at Sarov. This program, if successful, will reduce the size of the nuclear research center by one-third and eliminate nuclear weapons production at the nearby Avangard facility. This could serve as a pilot for future accelerated conversion of other sites in Russia's vastly oversized nuclear production complex.

It is also important to reduce the amount of new plutonium that is being generated by Russia's weapon production and nuclear power reactors. Los Alamos is working to provide technical measures to ensure that newly produced plutonium is not used to make additional nuclear weapons. Los Alamos is also seeking collaboration in the design of a proliferation resistant fuel cycle. Cooperative programs in this area could help influence Russia to minimize the proliferation risk in its nuclear transactions involving other countries, promote material disposition, limit environmental damage, and accelerate the conversion or elimination of military production reactors and unsafe designs.

B. Nonproliferation, Arms Control, and Monitoring. Restraining the proliferation of weapons of mass destruction and enforcing compliance with arms control agreements depends on a ready and reliable supply of technical information about activities in foreign states. This can be obtained by national and international methods of collection and analysis that stay ahead of efforts by aspiring WMD states to deny us this information. The national laboratories play a key role in developing the necessary tools and in providing trained experts to analyze the resulting information. The national labs also provide expertise and technology to help inhibit the spread of WMD material and technology.

In the case of preventing nuclear proliferation, control of nuclear materials at the source remains one of the most effective measures. As was made clear by the cases of Iraq and North Korea, international safeguards should be extended beyond traditional inspection and monitoring at declared sites to include wider scale monitoring of the environment to search for unauthorized nuclear activities. Measurement and monitoring technology exist to do this job, but they have not been brought to bear fully on this problem.

Similarly, better safeguards are needed for the stocks of civil plutonium that continue to grow in civilian energy programs, far outstripping the total amount of plutonium in all the weapon programs around the world. The accumulation of spent fuel at reactor storage sites is a global problem that will have to be dealt with in the next decade. The United States must engage with Russia, Europe, Japan, China and others on this issue if we are to seize this opportunity to reduce the risk of nuclear proliferation. Such a cooperative program would also allow the US to influence other countries to inhibit the transfer of WMD usable material and technology without adequate safeguards. Relevant technologies and institutional approaches under development at the national labs include modular, proliferation resistant reactor designs, accelerator transmutation of nuclear waste, and internationally safeguarded plutonium storage.

To monitor unilateral nuclear arms reductions and verify arms control agreements, and to provide information on nuclear weapon deployments, technological advances are also needed. Technical methods of monitoring – sensors and detection systems - and the means to analyze the resulting data -- are at least as important today as they were during the Cold War. The reasons for this are evident: China's modernization of its nuclear forces, Russia's interest in increasing its reliance on tactical nuclear weapons, and the intentions of several states to acquire nuclear weapons and the means to deliver them.

The US also needs the capability to detect a nuclear explosion anywhere, any time – whether underground, underwater, in the atmosphere, or in space – to verify nuclear test limits and to detect nuclear proliferation activities. This is important whether or not formal nuclear testing limits are in place. As long as there is a moratorium, the US will not test. But other countries might. It is also possible that a nuclear weapon could be used unexpectedly during a regional conflict somewhere in the world. National requirements have been levied for improved detection of underground and underwater nuclear explosions, and improved satellite based sensing of nuclear explosions in the atmosphere and space. However, some satellite sensors intended to meet atmosphere and space detection requirements are not currently receiving the support necessary for deployment and operation. These include the V-sensor slated for the GPS Nuclear Detonation System payload upgrade (Block IIF), and the high altitude and space detection package (space and atmosphere burst reporting system (SABRS)) which is intended to fly on the SIBRS-Hi satellites. These sensors, developed at the labs under the sponsorship of the DOE National Nuclear Security Administration (NNSA), need to be fielded on the respective satellite platforms to achieve the required monitoring capability.

Countries intent on acquiring weapons of mass destruction are becoming increasingly adept at avoiding detection by going underground and using benign civilian cover stories for covert military intentions. The basic technologies and scientific knowledge needed to develop at least crude mass destruction weapons are widespread. Especially in the biological and chemical arenas, it is difficult to distinguish benign civilian activities from activities having a military purpose. A new generation of more sensitive remote sensors and detection systems is needed to counter the increasing number of countries using denial and deception practices to mask weapon development programs. These new systems need to be sensitive to multiple types of signatures that are more difficult to conceal or masquerade as normal civilian activity. Because areas of concern in the world are increasingly widespread, the new systems must provide broad area coverage.

These remote sensors should be supplemented with relatively inexpensive, but capable, close-in sensors that can gather, analyze, and transmit information in autonomous and unattended fashion. These can be mounted on either fixed or robotic platforms. High-flying UAVs that can loiter for months carrying a suite of smart sensors may be another effective counter to denial and deception practices.

The national labs can participate in the development of new smart sensors and platforms, new microelectronics and advanced computational methods that will be needed to screen the immense amounts of data that will be generated by the new systems, and new computational search and visualization capabilities. Indeed, these technologies are akin to those being developed under the NNSA's stockpile stewardship program. This filtered technical information can be relayed to trained analysts with the scientific and technical background to perceive the implications of subtle indicators and pull out, if not the smoking gun, at least the indicators of weapon-related activity. This revolutionary new capability to monitor for proliferation-related activities across the entire globe at all times is the subject of the threat reduction initiative explored later in this paper.

C. Counter-proliferation and Counter-terrorism. Since the end of the Cold War the threat of mutual destruction has substantially decreased. But the types and number of threats to our national security have actually increased. These include nations of concern and terrorist organizations that threaten or carry out acts of violence against the US and other countries. Global security is continually at risk from the specter of drug use and drug traffickers, as well as the spread of chemical, biological, and nuclear weapons and their delivery systems.

US military superiority has spawned concerns regarding the possibility of asymmetric attacks on our overseas presence, bases and embassies, and even against our homeland. The threat of a nuclear or biological attack against a US city is real. The possibility must be taken seriously because the results could be catastrophic, even if the probability of such an attack is low. It does appear that the magnitude of violence employed by terrorists is increasing, while the means to inflict massive casualties and damage are proliferating despite our best efforts.

Technical responses to such threats, whether they be against military or civilian targets, have requirements in common. Both place a premium on intelligence, early warning and interdiction. Absent that, it is crucial to detect and characterize an event at the earliest stage. Recent Defense Science Board studies have concluded that against biological attacks, rapid detection and characterization save lives. Rapid response requires major improvements in public health surveillance and timely identification of specific pathogens. Without early diagnoses and medical intervention, say within 24 hours, the fatality rate increases rapidly. Researchers at Los Alamos have catalogued hundreds of strains of the anthrax-causing bacillus. This information has been used to identify the geographical source of anthrax, whether it is a new type of pathogenic strain or one that has been catalogued before. Los Alamos is working with the State of New Mexico, NIH and the CDC to develop early diagnosis of flu strains. Flu systems can mask a bioattack or the onset of an unsuspected new type of disease. Using modern information systems and computationally intensive forecasting tools, these efforts will help identify the onset of sickness and its potential spread from whatever the source, be it manmade or naturally occurring. By making these new tools widely available to our public health care system, we will improve disease prevention while, at the same time, increasing our ability to respond to a bio attack.

The ensuing emergency response efforts, to be effective, must be coordinated among several agencies – local, state and federal. All of this takes technology, training, and advanced preparation. We are only now beginning to acquire these capabilities. The NNSA's chemical and biological nonproliferation program (CBNP) has been a model of developing and demonstrating useful technologies to counter chemical and biological threats, applying as it does the scientific and technological expertise of the national labs to produce effective detection and response measures. This program needs to continue to grow to meet the challenge.

In the case of a nuclear threat to our homeland, the Defense Science Board recently proposed a series of specific measures designed to improve our capacity for detection and response. Initially, the US would develop a prototype system to detect covert delivery of a nuclear device at checkpoints around a US military base. There is also need for expanded mobile search and identification capabilities with improved detection systems. These technologies, developed to protect military bases, can be extended to protect the civilian population. Major improvements are needed in nuclear forensics – if a nuclear device or material is discovered, national authorities need to know the source in hours or at most days, not the current weeks to months. Clearly, the US response to nuclear terrorism against our homeland or overseas presence would differ if it came from a terrorist group rather than from a state. National authorities need to know the source as quickly as possible.

D. <u>Defense Science and Technology.</u> In an increasingly sophisticated, interconnected world, US military forces are constantly facing new challenges that can impact future missions. Science and technology advancements can assist our forces to stay ahead of our adversaries and be ready to meet new dangers. As major elements of the nation's defense science and technology base, the national labs contribute much to broader national defense. Today the NNSA labs contribute mostly through federal work for others arrangements. In a few cases the work is governed by MOU's (eg, the conventional munitions MOU between NNSA and DoD) or by MOA's (eg, the MOA's covering NNSA developed monitoring technology supplied to the Air Force).

The labs could be much more effective under partnerships established between NNSA and major DoD elements such as the Defense Threat Reduction Agency. Overall partnerships should be codified under umbrella MOU's with subsidiary MOA's delineating specific work scope. Annual updates of progress by senior agency officials and selection of programs that mutually benefit both agencies would help ensure that the partnerships are serving the interests of both parties. The total funding for the labs from these agencies is already several hundred million dollars, but most of it is in the form of piecemeal projects funded through the existing work for others process. The advantage to NNSA of a MOU approach is assurance that the portion of the labs' scientific and technical capability primarily directed to DoD Research is underwritten by DoD. The advantage to DoD of such an approach is its ability to use the labs more efficiently to solve highly complex technical problems at reduced cost, eg, by eliminating the FAC, and more predictability of what DoD should expect to get for its investment.

MOU's could be especially fruitful with DoD's BMDO, DTRA, and DDR&E. All have research needs that overlap extensively with lab capabilities. Following an intensive review of BMDO's needs and lab capabilities, we have worked jointly to define specific areas where the labs can make significant contributions to challenging BMDO problems. We have also found that DTRA and NNSA missions are highly complimentary, as DTRA is responsible for many military needs related to WMD. Similarly, DDR&E is responsible for broad S&T policy and investment strategy for the DoD.

E. <u>Critical Infrastructure Protection.</u> The prosperity and security of the United States is highly dependent upon its physical and cyber infrastructure. The nation has elaborate power, water, and communications delivery grids that are operated independently but that are highly interdependent. The efficiencies undertaken following deregulation have most of our infrastructure operating at near capacity. Understanding and then mitigating the interdependencies and potential vulnerabilities of these systems is tremendously complex. Assuring the security, continuity, and availability of our critical infrastructures must be a top national priority, but there is little R&D effort focused on protecting the nation's critical infrastructure today. DOE and NNSA could go a long way towards filling this gap by extending ongoing counter-proliferation and counter-terrorism R&D to focus more on protecting infrastructure.

At Los Alamos we have built upon our TRANSIMS (transportation simulation) program to create a model of the national electric grid. Under deregulation the electric grid is currently suffering severe stress. Similar stress applies to virtually all our energy-related infrastructure. We are now looking at mutual dependencies and vulnerabilities among the transportation and energy systems. Only now have modern computational and analytical methods made it possible to make realistic vulnerability assessments of these massively complex and interconnected systems. Such knowledge and predictive tools are valuable in looking at vulnerabilities caused by unanticipated system failures or malevolent attacks. Similar thinking can be extended to assess many naturally occurring and manmade impacts on our society, including energy, environment, and natural disasters. The labs have the tools and highly skilled people to produce valuable insights for future policy and decision-makers.

III. Threat Reduction Initiative

In the next two decades we can expect a growing threat of asymmetrical responses to American dominance. These challenges can come in many forms, but weapons of mass destruction, especially biological and nuclear, and their delivery systems, pose a particularly galvanizing threat to our allies and military overseas and to our homeland. To respond to this threat, we need a deep understanding of activities in denied areas, at a level never before possible. We also need the ability to track activities in our own homeland, should these terrible devices appear on our shores. This will require advances in sensors, processing, and analysis, assembled into an integrated capability. The time is ripe for research and development that can give us these capabilities. The Nonproliferation and International Security Center (NISC) under construction at Los Alamos will provide a focused environment to research and develop new capabilities.

Sensors: On the horizon are remote sensors that can allow us both to look more deeply at any given location on the Earth, and to survey the whole Earth for emerging threats. For particular locations, we expect the next decade to move us more and more deeply into multi-dimensional remote sensing. Moving beyond the two-dimensional snapshots, taken at a single instant in time - the current state of the art - we can move into additional dimensions of volume, time, and spectrum. This kind of information will help us to understand activities at proliferant sites and overcome denial and deception.

Certain threats can appear anywhere on the Earth at any time. To address them, we need synoptic whole-Earth surveillance – that is, techniques for monitoring the whole Earth and a sensitivity adequate for WMD threats. Today we have this capability to monitor for nuclear explosions in the atmosphere and near-Earth space. In the next decade, we can demonstrate the utility of a distributed system for remote sensing of much more subtle emanations from WMD proliferants. Such a system could find a home on an array of micro-satellites, as a small add-on to one of the upcoming low-earth orbit (LEO) constellations, or as part of high flying, long duration UAVs. Success will require R&D in the miniaturization of processing, in intelligent feature identification, and in understanding the signatures given off by proliferation processes.

Some signals cannot be sensed at a distance. These include faint emissions like radio whispers from instruments and machines, vibrations in the earth and atmosphere, and particulates such as the spores of biological weapons. These require a new generation of unattended close-in sensors. To achieve these, we will need to develop miniaturized sensors, novel power supplies like fuel cells, new schemes for processing data at the sensor and, even more exciting, a virtual computer distributed across the sensor net to collect and process data. A related opportunity may be the extraction of data by radio, laser, or other techniques. Networks of sensors coupled to modern computing and information systems offer the best hope of early detection and warning of an attack on our homeland that might cause massive casualties and/or cripple our infrastructure.

Processing. In past decades, the new sources of data discussed above would have been useless because they could never be exploited. Moore's Law – the unstopping increase in computational capability that has brought us the Information Revolution – will make these impossible things possible. With ever more powerful computer hardware, new architectures for processing data, and new processing algorithms, we will be able to exploit data from multidimensional sensors on a timely basis. These new sensors and networks need to process raw data early in the information flow, so as not to immobilize downstream information networks with large masses of unfiltered raw data. The national labs are researching the tools we need; this work includes computers that can be reconfigured on the fly and processing architectures that initially process data where it is found, at the sensor head and in memory.

Once information is processed, it must be mined for knowledge. Computers using massively parallel architectures are starting to show value in helping people understand images. As they should, these tools assist, rather than replace, the analyst. We are conducting research into artificial vision and neuromorphic processing. These are tools to exploit imagery with ever-increasing levels of sophistication, ranging from feature identification up to object recognition, using techniques inspired by the human visual system. These tools could be used to address problems in surveillance, intelligence, and other national security areas. Los Alamos has a running start in this area, with successful programs in genetic imagery exploitation (GENIE), syntactic image understanding, and web-based smart cameras.

Analysis and assisted reasoning. To successfully extract understanding out of processed sensor products requires an integrated analysis approach, organized around the problem, not the tool. By fusing multiple sources of information, we can learn things that are not evident in any single data set, and the use of multiple data sets makes it more difficult for adversaries to deny and deceive our collection tools. A promising approach is to organize intelligence analysis on a site or network-specific basis, taking full advantage of modern information tools and new sensing methods tailored to each specific problem. R&D into new computational tools is essential, in order to organize, integrate, correlate and display the data streams that need to be brought to a common focus to assist human reasoning in resolving hard, integrative problems. These assisted reasoning tools are meant to expand human judgement, just as technology has expanded the power of humanity in many other areas. If they succeed, they will carry some part of knowledge held by human experts into computers, so that computers can share the burden of analysis.

Bringing it all together. A major new facility, the Nonproliferation and International Security Center at Los Alamos, is scheduled for occupancy in 2003. The opening of this site offers a special opportunity to integrate scientists, technologists, and analysts in a focal point in the heart of one national lab, a short drive from another lab, and bound by cyber connections to all players nationally. In order to create this revolutionary leap forward in threat characterization and analysis, we must begin planning now. Some of the needed sensors, platforms and analysis systems are already being developed at the national labs. At least one is undergoing prototype demonstration on a research satellite sponsored jointly by NNSA and the Air Force. But there need to be better mechanisms for transferring technology to system operators and users in other federal agencies and, in turn, better ways for national lab experts to access information from these agencies. We already plan to consolidate laboratory sensor and detector experts, data and computational analysis experts, and scientifically trained specialists who know what tell tale signs to look for indicating covert WMD programs. We can build on this initial capability to develop a virtual, integrated national test bed for the development and exploitation of new sources of information. Our vision is to develop the capability to monitor the entire globe at all times for indications of WMD activity.